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ORIGINAL MEMOIRS.

INVAGINATION OF MECKEL'S DIVERTICULUM.

REPORT OF A CASE AND A STUDY OF THE LITERATURE.

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A PERSISTENT Meckel's diverticulum in the human body is at all times a serious menace to life. It has been roughly estimated that this anomaly is present in 2 per cent. of bodies (this figure is probably too low), and it is likely that few persistent diverticula exist without giving rise to some marked symptoms.

The mortality from intestinal obstruction and peritonitis due to this abnormality is so high that it would not only be justifiable, but necessary, to remove this structure by operation, could a diagnosis of its existence be arrived at before serious symptoms necessitate an urgent operation under usually unfavorable conditions.

The foregoing opinion has led me, during the past few years, to make a special study of this variety of intestinal obstruction; and, since the subject is too large to be dealt with in a single paper, I propose to consider *"Invagination of Meckel's Diverticulum"* and its complications. A case of this nature has recently come under my observation, and presents many points of interest: the child was under the care of Mr. Arbuthnot Lane, to whom I am indebted for his courtesy in permitting me to publish the case.

The details are as follows: Alfred B., male, aet. 8 years. Admitted into the Hospital for Sick Children, Great Ormond Street, February 5, 1908.

Past History.—The mother states that as a baby he passed blood in the motions once, after a dose of salts. At 5 years, he had a definite attack of violent abdominal pain accompanied by vomiting and the passage of blood "per rectum." This attack lasted one day, after which the symptoms passed off. The mother had further noticed that frequently, on going to stool, the child "stamped and went white as if in pain," but made no complaint.

History of Present Illness.—The onset of the present attack, on Thursday, January 30, was characterized by severe pain in the "lower half of the stomach" (the child pointed across the umbilicus when questioned). The pain continued on the 30th and 31st of January, though the child attended school.

On February 1, the bowels acted as a result of some licorice powder, the pain diminished, and he felt better. Patient felt better till the afternoon of February 2, when, while at Sunday school, he was attacked with violent abdominal pain. The bowels acted. February 3, pain was more acute; retching supervened and from this time onwards there was absolute constipation. February 4, child quieter, but refused food; vomited three times. February 5, vomited three times. The mother thinks there was some blood in the vomit. *No blood was at any time passed per rectum.*

State on Admission.—Temperature, 101° F.; pulse, 100. Patient looked ill. Facies of the abdominal type.

Abdomen.—Considerable distention, especially above the umbilicus. The contour of the abdomen conformed to the type of a small intestine obstruction and distended coils of gut were clearly outlined. Movement was free everywhere, while there was no tenderness or rigidity. No tumor was felt.

When in bed the child slept for about an hour and seemed comfortable. Examination of the rectum, which was filled with scybala, was negative. The *umbilicus* was raised and dome shaped, and the skin was of a bluish tint and scarred to a marked degree; the abnormality was sufficient to attract attention at once. A high enema yielded no result. The tongue was brown but moist: in fact the general condition, in spite of a history of seven days, was comparatively good. The bladder was distended and a considerable quantity of urine was drawn off by a catheter before operation.

In view of the fairly characteristic past and present history and the condition of the umbilicus, intestinal obstruction, due to a persistent Meckel's diverticulum was suspected; the real nature of the case was made clearer by the palpation of a sausage-shaped tumor lying beneath the liver, before opening the abdomen, when the patient was under the influence of chloroform.

Operation.—The abdomen was opened by a 4-inch incision by splitting the fibres of the right rectus. A good deal of straw-colored fluid escaped on opening the peritoneum, and the intussusception was immediately found with two fingers in the abdomen. Reduction was effected by manipulation till the cæcum was free of contents, when it was found that an irreducible enteric intussusception remained, which had caused the ileocæcal one, now reduced. The irreducible mass was about 4 inches long and extended to 3 inches above the ileocæcal valve; while through the intestinal wall, below the presenting part, could be seen and felt a polypoid mass projecting into the lumen of the termination of the ileum.

The intussusception, with two inches of healthy gut above and below was excised, thus leaving 1 inch of healthy ileum adjoining the cæcum. During the operation saline infusion had been administered, and, since the child's condition was fairly good, an immediate axial anastomosis was decided on. This procedure was accomplished in the usual way, and the abdomen sewn up in layers; the operation lasting a little over 1¼ hours. The patient stood the operation well and gave no cause for immediate anxiety till about 6 hours later, when froth tinged with fæces persisted in coming from the nostrils, a condition which continued until death 15 hours after operation (a motion containing blood and mucus had been passed shortly after the child was returned to bed).

At the autopsy, the anastomosis proved in every way satisfactory and there was no sign of infection of the peritoneum.

Examination of the Specimen (see Fig. 1).—On opening up the specimen it was seen that the intussusception had been started by an invaginated Meckel's diverticulum about 2½ inches in length. All the coats were completely invaginated and, with the intestinal wall involved, quite gangrenous. Just below the origin

Number.	Author.	Sex.	Age.	Previous abdominal crises.	Duration of final attack.	Remissions in major attack.	Onset during rest or active movement.	Passage of blood per rectum.	Passage of fæces or flatus.
1.	Gray............	M.	8 years	2 Definite, probably more.	7 days	One	Active movement	None	Two stools
2.	Watson-Cheyne...	M.	19 years	Many	7 days	Two	Rest	None	One stool
3.	Von Mandach.....	M.	2½ years	None	7 days	None	......	None	Diarrhœa
4.	Bidwell..........	M.	3½ years	Many	8 days	Oper.	Active movement	None	None
5.	Robinson.........	M.	5 years	Many indefinite	2 days	One	......	None (enema tinged)	One stool
6.	Weill & Frankel...	F.	4½ years	None	1 day	None	......	Melæna	None
7.	Holbeck,[29]........	M.	18 years	None	3 days	None	......	None	None
8.	De Quervain......	M.	16 years	....	2 days	None	......	None	Many stools
9.	VonStrubenrauch,[30]	F.	5½ years	....	5 days	....	......	Yes	Many stools
10.	Brunner..........	M.	4 years	None	3 days	None	......	Yes	None
11.	Terry............	M.	12 years	....	½ a day	None	Activity	Yes	One stool
12.	Travers,[31].........	M.	10 years	....	1 day	None	......	None	None
13.	Morrison,[32]........	M.	5 years	....	1 day	None	......	Yes	....
14.	Wainwright.......	M.	17 years	None	1½ days	Gradual onset	Activity	None (enema tinged)	None
15.	Adams...........	M.	42 years	One	More than 7 days	....	......	None	....
16.	Zum Busch......	M.	21 years	Many	2½ days	None	Activity	Yes	? several motions
17.	Coffey...........	M.	7 years	Numerous	4 days	One	......	None	Two motions, flatus also
18.	O'Connor.........	M.	13 years	....	....	None	......	None	None
19.	Pitts,[33]...........	F.	8 years	....	5 days	....	......	None	4 motions
20.	Eve,[34]............	M.	13 years	....	28 days	....	......	....	....

Situation of pain.	Tenderness.	Meteorism.	Abnormality of umbilical cicatrix.	Palpable tumor.	General condition compared with duration of final attack.	Operation.	Result.	Appearance of Diverticulum, etc.
Umbilical region	None	Gen'l.	Marked	Only under anæsthetic	Good	Yes (Res.)	Death	Gangrenous, slightly club-shaped, all coats of Diverticulum invaginated. Small degree of stenosis of gut.
Epigastrium	1½″ below umbilicus	Varying	......	Yes	Good	Yes (Res.)	Recovery	Much inflammatory thickening. Only mucosa invaginated. Inflammatory stenosis of gut.
....	....	Gen'l.	......	....	Good	Yes (M. Red.)	Recovery	....
....	....	......	Umb. hernia	Yes	......	Yes (Res.)	Recovery	....
Umbilicus	None	Gen'l.	......	Yes	Bad	Yes (M. Res.)	Death	....
....	....	......	......	....	......	Yes (Res.)	Death	....
....	None	Gen'l.	......	Only under anæsthetic	......	Yes (M. Res.)	Death	....
....	....	Gen'l.	......	None	......	Yes (Res.)	Death	Diverticulum gangrenous, all coats invaginated.
....	....	......	......	Yes	......	Yes (Res.)	Death	....
....	....	Gen'l.	......	Yes	Bad	Yes (Res.)	Recovery	Accessory pancreas on apex of Diverticulum (? a real Meckel's diverticulum.)
Just below and to the right of umbilicus.	....	......	......	....	Good	Yes (M. Res.)	Recovery	....
Right side of abdomen.	....	......	......	Yes	......	Yes (M. Red.)	Recovery	....
....	....	......	......	Yes	......	Yes (M. Res.)	Recovery	....
Lower zone of abdomen.	Situated with the pain	None	......	None	Good	Yes (M. Res.)	Recovery	....
....	....	......	......	None	Good	None	Death	Evidence of previous inflammation of Diverticulum.
Umbilicus.	....	......	......	Yes	? Fair	Yes (Res.)	Recovery	Subserous lipoma at apex of Diverticulum.
....	....	......	......	Yes	Good	Yes (Res.)	Recovery	Intussusception and Diverticulum gangrenous.
....	....	......	......	None	Good	None	Recovery	Intussusception sloughed out per rectum.
....	....	......	......	Yes	Good	Yes (Res.)	Recovery	Gangrenous.
....	....	......	......	....	......	Yes (Res.)	Death	....

Number.	Author.	Sex.	Age.	Previous abdominal crises.	Duration of final attack.	Remissions in major attack.	Onset during rest or active movement.	Passage of blood per rectum.	Passage of fæces or flatus.
21.	Erdmann,[35].......	F.	9 years	....	2½ days	None	Activity	Yes	None
22.	Ingle,[36]...........	..	$\frac{5}{12}$ years	....	5 days	None	......	Yes	None
23.	Cawardine........	..	1$\frac{7}{12}$ years	....	2 days	....	......	....	....
24.	Küttner..........	F.	49 years	One marked	3 days	None	......	None	None
25.	Maroni...........	M.	26 years	....	....	....	......	....	....
26.	Ewald............	..	....	Many marked	....	....	......	....	None
27.	Strauch..........	F.	6 years	Many marked	2 days	None	Rest	None	Numerous motions
28.	Bayer,[37]..........	M.	2½ years	....	....	....	Activity	....	....
29.	Rehn.............	M.	30½ years	Many	Chronic	Many	No definite onset	None	Many motions
30.	Jākch............	F.	30 years	Many	Chronic	Many	No definite onset	None	Many motions
31.	Forgue & Riche...	M.	60 years	....	....	Partial obstr.	......	....	?
32.	Guyot,[40]..........	M.	6 years	....	5 days	....	......	....	....

No.	Author.	Further cases of which no clinical details are given.
33.	Heller............	Worm-like Diverticulum with lumen obliterated in lumen of intestine. Found at autopsy.
34.	Heller............	Movable cord in lumen of intestine with accessory pancreas at apex. Found at autopsy.
35.	Heller............	Specimen.
36.	Treves...........	Specimen in Guy's Hospital Museum.
37.	Treves...........	Specimen in Royal College of Surgeons.
38.	Adams,[38].........	Specimen from a case ending fatally after 14 days acute illness.
39.	Studsgaard,[39].....	M. aet. 37 years. Resection. Death. Intussusception caused by invagination of Meckel's Diverticulum.
40.	Boldt............	Child. Invagination of Diverticulum (? Meckel's) started an intussusception.

Situation of pain.	Tenderness.	Meteorism.	Abnormality of umbilical cicatrix.	Palpable tumor.	General condition compared with duration of final attack.	Operation.	Result.	Appearance of Diverticulum, etc.
Right side of abdomen	....	Gen'l.	......	....	Bad	Yes (Res.)	Death	....
....	....	Gen'l.	......	None	Bad	None	Death	....
....	....	......	......	....	......	Yes (M. Red.)	Death	....
....	Situation not stated	Marked and gen'l.	......	None	Fair	Yes (anastomosis only)	Death	Club-shaped. Evidence of previous inflammation. Invagination of Diverticulum only. 3 perforations.
....	....	Gen'l.	......	....	......	Yes (obstruction not removed).	Death	Diverticulum only invaginated. Polypus the size of a cherry attached to base of Diverticulum.
....	....	......	......	....	......	None	Death	Invaginated Diverticulum only. Also stenosis of gut at its attachment due to inflammation.
....	Present situation not stated	Gen'l.	......	Yes	Good	Yes (Res.)	Death	Club-shaped. Evidence of previous inflammation.
....	....	......	......	Yes	......	Yes (M. Red.)	Recovery	....
Burning pain at umbilicus.	....	......	......	Yes	Good	....	....	Club-shaped. Intussusception started above Diverticulum which was probably invaginated independently.
General	....	Gen'l.	......	Yes	Good	Yes (Res.)	Recovery	Club-shaped; lumen obliterated by inflammation converting Diverticulum into a polypus.
....	....	......	......	....	......	None	Death	Invagination of Diverticulum only.
....	....	......	......	....	......	Yes (anastomosis only)	Death	Gangrenous.

N. B.—Res. = resection of intestine.
M. Res. = resection of Meckel's diverticulum.
M. Red. = invagination of Meckel's diverticulum reduced.

of the diverticulum from the opposite mesenteric border, the intestine was considerably stenosed (Fig. 1). The total amount of Intestine resected was about 18 inches.

This case is a most instructive one and full of interest; while the points to which I particularly wish to draw attention are drawn up in an appended table. (See Table.) I have been able to collect 39 cases of Invagination of Meckel's Diverticulum which, with my own case, make up a total of 40.

The condition is not common, though, I believe, not as rare as is generally supposed. An invagination of Meckel's diverticulum has usually produced an intussusception of the intestine also; out of the 40 cases I have collected, in 7 only was the diverticulum alone invaginated, while one of these was involved in an intussusception arising above the attachment of the diverticulum to the gut, and was therefore probably of independent origin (Rehn[1]).

Forgue and Riche[2] give these figures as 6 out of 33, while now with the additional cases I have collected, the figures are 6 out of 40. That is to say, invagination of Meckel's diverticulum alone occurs in 15 per cent. of cases and causes intussusception of the intestine in 82 per cent.

The reason, in the first place, for the rarity of this lesion is that, for such an occurrence, the diverticulum must be free, and this is the most uncommon condition met with.[3] Usually this structure acquires a secondary attachment to the mesentery or more rarely the intestine, and less commonly still remains fixed to the umbilicus.[3] In the second place, once invaginated into the lumen of the intestine, Meckel's diverticulum acts like a polypus in tending to produce an intussusception.

Sex.—This appears to be a matter of some importance, for, out of the 30 cases in which the sex is mentioned, 23 were males and 7 females, giving a figure of 76 per cent. males. Now this marked preponderance of males over females does not agree with anatomical findings, and one can only conclude that this structure, when present, is more likely to give rise to symptoms in males than females. This, as a fact, is the case; and the reason will be shown later.

Age.—This is a matter of some weight in diagnosis, for the average age at which the final attack has occurred is 15 years. Out of 32 cases where the age is stated, 16 (50 per cent.) were under 10 years, 9 between 10 and 20 years and 8 over 20 years, while it is important to note that only 2 cases occurred under 2 years, the *commonest age* for the occurrence of intussusceptions; this will be again referred to later.

The commonest period of life, then, for this lesion is childhood and early adult life.

History of Previous Abdominal Crises.—I cannot lay stress too insistently on the importance of obtaining a most accurate history of past ailments, however trivial, in any case of acute abdominal disease—out of the 17 cases where the past history is detailed, in 12 (70 per cent.) was a definite account of previous abdominal crises obtained. Recurrent abdominal crises are common, and constitute a most important symptom, in persons harboring a persistent Meckel's diverticulum;[4] and, in many of the cases appended, the history alone, in my opinion, was sufficiently definite to warrant an exploration before the onset of acute symptoms.

To quote briefly from some of these histories: In my own case, the patient passed blood, even as an infant, had a violent attack of abdominal pain accompanied by vomiting and the passage of blood at 5 years, and appeared to suffer frequently on going to stool. In Watson Cheyne's case[5] the man complained of abdominal discomfort for two years leading up to an attack of diarrhœa and vomiting 8 months before coming under observation. These crises with flatulence and vomiting increased from fortnightly to weekly intervals, gaining always in intensity.

Bidwell's case[6] had a severe hemorrhage from the rectum 6 months previously, and upon this supervened weekly attacks of abdominal pain and vomiting *on rising in the morning*, which passed off after an hour or so.

Robinson's case[7] complained of occasional abdominal pain, and that reported by Zum Bush[8] gave a similar though more definite account of recurring crises.

In this connection Coffey's case[9] is well worthy of note, for this child 5 years previously was attacked with severe abdominal cramps with cold sweats and vomiting, which lasted 36 hours, and was followed by similar attacks every month accompanied by the passage of blood per rectum on each occasion.

Küttner's[10] and Adams's[17] patients had previously suffered from an attack of acute intestinal obstruction, which had subsided spontaneously, while Ewald[11] reports a similar attack followed by recurring crises leading to a diagnosis of intestinal stenosis. Strauch,[12] Rehn[1] and Jäkch[13] all report perfectly definite attacks of violent abdominal colic or cramps, varying in their intensity, their persistency, and in their concomitant symptoms.

The above cases well repay perusal, and I can only repeat that such accounts, especially in the presence of other signs, should warrant a strong suspicion of the presence of a Meckel's diverticulum.

As regards the explanation of these crises, I have elsewhere[3] remarked on the liability to twisting and consequently slight attacks of inflammation to which such a structure is liable, especially in view of its poor blood-supply: while the laxity of its mucous membrane,[5] in a free diverticulum, added to such attacks of inflammation, renders it prone (as I hope to show later) to recurring partial invagination which would well account for the frequent passage of blood in many of the recorded cases.

The Onset, Character, and Duration of the Final Attack.—When a case is finally under observation for the treatment of acute symptoms, it is often of considerable importance to arrive at an accurate diagnosis, especially as the general condition in many of these patients we are considering is, in my experience, particularly apt to be misleading as regards the severity of the lesion. If column 15 in the table be referred to, it will be seen that I have attempted to arrive at a reasonably accurate conclusion from the data as to the condition of the patient when compared with the duration of the attack. It seemed to me, on reading the reports, that the condition was good or fair in 14 and bad in 4 out of the 18 cases where I was able to form an opinion. Some stress is laid on this, because in my own case I was nearly misled by the comparatively excellent condition of the boy (he was seen on the seventh day of the attack) who slept comfortably for over an hour on admission, and did not complain of pain; while there was no evidence of peritonitis.

The explanation is that the early symptoms are due to the invagination, or inflammatory attacks preceding the invagination, of the diverticulum itself, while the succeeding intussusception or gangrene of the intestine often does not occur till a day or two later. The duration is in consequence longer and the patient's condition better than might be expected, while the illness tends to start somewhat gradually and increase in intensity to the climax, when the more serious lesions supervene. This is a point of importance in the diagnosis from volvulus, for which the condition has been mistaken (Küttner [10]).

It would be expected from the above remarks that remissions, or temporary relief, would be observed during the final attack; this in fact has been remarked in several cases. These remissions are well illustrated in the history of the case here reported, as also in Watson Cheyne's case.[5] Coffey's case [9] is no exception, while Rehn's [1] and Jäkch's [13] cases show how this feature can be so marked that the onset is subacute or chronic in nature: in the former case there were never any acute symptoms, the operation being performed at the most favorable period, *i.e.*, before the onset of any acute symptoms.

Another important point in this connection is the time of onset. In every case where the point is mentioned, except that of Strauch,[12] the acute symptoms started during activity. As a contrast, acute appendicitis, which is closely simulated by this condition, commonly starts while the patient is at rest, and usually in the early morning. Thus my case was at school at the time, while in Bidwell's[6] the attacks occurred "on rising in the morning." Terry's case[14] was at school, Wainwright's,[15] out for a walk to get rid, apparently, of the discomfort and fulness, etc., from which he had been suffering from some days previously. Zum Busch's[8] patient was an acrobat, and the history of this case is particularly interesting. Kelly[16] gives a list of the factors tending to produce torsion of Meckel's diverticulum which, I believe, precedes invagination—amongst these are the perpetual movement of the intestines, and the continual play of the abdominal muscles. This accounts for the frequency with which the minor crises, as well as the final acute illness, take place, when the abdominal muscles are being used; and it also explains to some degree the large preponderance of males over females, whose lives are so much more sedentary. In this connection it is also interesting to note that infants are almost exempt, for only two cases occurred under 2 years, while children under 10 years show the highest percentage, and this age is that of the greatest activity.

Thus in my case, the child appeared to suffer pain on going to stool, while in Brunner's[21] the onset took place immediately after opening the bowels; this last feature I have noticed in acute lesions of Meckel's diverticulum other than invagination. As regards the duration of the final attack, if the chronic cases be excluded, the average figure was 3½ days, though 12 cases showed a history of over 5 days duration.

Finally in connection with the onset, the character of the pain is always severe, usually violent, and frequently situated in the umbilical region. It has been variously described as colicky, cramp-like, and on one occasion it was preceded by burning pain at the umbilicus (Rehn[1]). Vomiting is a constant symptom.

Passage of Blood per Rectum, etc.—In spite of the frequency with which invagination of Meckel's diverticulum leads to intussusception, it is a curious and noteworthy point that a large number of cases pass no blood during the final attack.

Thus out of 25 cases, in which this sign is referred to, only 7 passed bright blood (28 per cent.), one suffered from abundant melæna (Weill and Fränkel[18]) and 17 passed no blood at all (68 per cent.). In two of these 17 cases the enema was tinged with blood only (Robinson[7] and Wainwright[16]). This is a noteworthy diagnostic feature, for the palpation of the characteristic tumor together with this negative sign would seem to warrant a suspicion of the real nature of the lesion. If the table be referred to, it will be noticed that those cases in which blood was passed were mostly those with a short history; it seems probable, therefore, that the invaginated diverticulum becomes gangrenous early (it will be remembered that the blood supply is nearly always derived from that of the adjacent intestine, and is of the poorest) and a certain amount of paralysis of the intestine ensues which prevents the blood from being passed. In support of this, my own case passed blood with a motion after the operation. Another striking feature is that constipation is seldom absolute (11 cases out of 24); 13 cases, or over 54 per cent., passed at least one motion, several passed more than one, while diarrhœa was a feature in Von Mandach's case.[10] This characteristic is in keeping with the nature of the onset and may prove of considerable aid in establishing a diagnosis.

Tenderness as a rule is not present in any degree, unless peritonitis has set in, when it is diffused.

Meteorism is general, when present, and the shape of the abdomen conforms as a rule to the type usually seen in a small intestine obstruction; distended coils of gut are frequently visible. There is, in this class of case, no localized meteorism so characteristic of strangulation by a diverticulum.[3]

A Palpable Tumor is mentioned 16 times, its detection occurring twice under anæsthetic only; probably distention, which is commonly present, prevented a satisfactory examination in the remaining cases, or the diverticulum only was invaginated.

Abnormality of Umbilical Cicatrix.—I have elsewhere[3] drawn attention to the value of this sign in the diagnosis of the presence of a Meckel's diverticulum, and for details I would refer the reader to that paper. I will only emphasize here that, when present, it has proved of great value in the recognition of the cases which have come under my personal observation, and, in the present report, was of considerable assistance in the formation of a correct diagnosis. I regret that unfortunately no photograph was taken of this child's umbilicus.

As to the frequency with which this sign is present, it is impossible to make a statement, since no mention is made of it by any author except Bidwell,[6] who only remarks on a previous umbilical hernia, for the cure of which he had operated.

Pathology.—Several views have been advanced to account for the invagination of the Meckel's diverticulum, which must of necessity be lying free in the abdominal cavity. Such free diverticula are particularly liable to undergo torsion about their own longitudinal axis. Any one of these accidents may prove fatal, by causing gangrene of this structure; many such cases have been reported,[3] though it is foreign to my purpose to discuss them now. Repeated slight torsions would have the effect of causing some degree of obstruction at the attached end, with consequent œdema and swelling of the free end, and also with the outpouring of mucus into the lumen of the diverticulum. Evidence of this is seen in examining specimens in which the diverticulum is usually club-shaped, its bulk narrowing to a neck at the point where it is attached to the intestinal wall. Evidence of inflammatory thickening at this spot, even extending to, and causing stenosis of, the neighboring intestine, is mentioned by several authors in their reports. Thus Watson Cheyne,[5] Adams,[17] Küttner,[10] Ewald,[11] Strauch,[12] Jäkch [13] and Heller,[20] all describe such pathological evidence, while to this may be added my own case.

The following explanations of the process of invagination have been given:

Küttner [10] says that invagination is set up by the presence of an accessory pancreas, a polypus, or a fecal mass in the diverticulum.

An accessory pancreas situated at the tip of this structure is mentioned by Brunner[21] and Heller,[20] while in Zum Busch's case[8] there was a subserous lipoma in the same situation. Such tumors would, in my opinion, tend to prevent, rather than to assist, invagination; and even if they did explain the process in these cases, to the majority, in which no such tumors are found, some other mechanism must be assigned.

A polypus when present would undoubtedly account for invagination. In Maroni's[22] case a polypus the size of a cherry was probably responsible, but this tumor, it should be noted, was attached to the base, and *not* the apex of the diverticulum.

The fæces to play any active part must be very problematical, in view of the fluid nature of the contents of the small intestine.

De Quervain's[23] explanation, that a rush of fluid along the intestine produces a negative pressure in, and so invagination of, the diverticulum, we can disregard as being too fantastic.

The most reasonable explanation seems to me that the invagination starts at the base and not at the apex, as has been assumed. Slight torsions, the symptoms of which have been noted in many cases, produce congestion, swelling, and a quantity of mucus in the lumen of the diverticulum. Now it has been noted that the mucosa of this structure is loosely attached to the muscular wall (Watson Cheyne[5]); so loose is it that the mucous coat alone can be invaginated.[5] The consequent swelling of the mucosa and its separation by serous effusion from the muscular coat (aided perhaps by bacterial infection) produce a closure of the orifice into the intestine, and efforts to expel the accumulated contents succeed only in squeezing the mucous coat into the intestine, which would ultimately drag after it the muscular and serous coats also. The invagination would thus start at the neck or base; and the swelling is progressive, on account of the contraction of the circular fibres behind, thus tending to prevent a return to the normal condition. Intussusception of the intestine may follow immediately, or the mass may hang free in the intestinal lumen and give rise to recurrent attacks of hemorrhage, etc., symptoms which we have seen are often characteristic of these cases.

Repeated attacks of inflammation or mechanical congestion in such an invaginated diverticulum, if an intussusception is not produced, will cause the fusion of the now adjacent serous surfaces and an intestinal polyp is produced. I think this may be the real origin of some, at any rate, of the so-called high intestinal polyps, which are said to cause hemorrhage from the bowel and sometimes an intussusception. Specimens can be seen illustrating this transformation of an invaginated Meckel's diverticulum into an intestinal polyp, though more observations are of course necessary to establish such a statement (Jäkch,[13] Heller[20]).

Prognosis.—When acute symptoms have supervened, the prognosis is very grave, while, if operation is practised during the quiescent stage (or when symptoms are only subacute or chronic) the outlook is more hopeful. Thus of the two chronic cases operated on, one recovered and in one the result is not stated (Rehn[1] and Jäkch[13]). No details are given of Boldt's case.[24] The lesion was discovered at autopsy in two cases (Heller[20]), death presumably occurring from other causes. Three cases are specimens only (Heller,[20] Treves[25]). Of the 32 cases left, where an adequate clinical account is given, 13 recovered and 19 died, a mortality of nearly 60 per cent. Six cases were not operated on and only one of these, O'Connor's,[26] recovered by the sloughing of the whole intussusception, which was passed per rectum about the sixth or seventh day. Twenty-seven cases were operated on with 14 deaths and 13 recoveries—a mortality of about 52 per cent.

Of these 27 cases operated on: *resection of intestine* was practised 15 times, with a mortality of 53 per cent.; but it will be seen in the table that 9 of these cases were under 12 years of age, while over that age the mortality was 50 per cent. The mortality, therefore, in cases of resection appears to be between 50 per cent. and 60 per cent., independent of age, though such figures are not of very great value when calculated from so small a number of cases. *The diverticulum alone was removed* 5 times, with 3 recoveries and 2 deaths. And, considering that the age of 2 of the cases was over 5 years and of the other 3 between 10 and 20 years, 60 per cent. mortality is a high figure, in view of the comparative insignificance of the operation. *Reduction of the invaginated diverticulum* without *subsequent removal* was practised in 4 cases, of which 3 recovered. The case which died is reported by Cawardine,[27] and here an intussusception had to be reduced also, while the age of the infant was 1 year and 2 months (mortality 25 per cent.).

In two cases entero-anastomosis only, above and below the seat of obstruction, was practised with a mortality of 100 per cent.; while in one case the obstruction, which the operation failed to relieve (Maroni [22]), led to a fatal termination. It would seem, from the figures, that reduction only, where feasible, has given the best results; but it is questionable whether it is wise to leave the diverticulum, in view of the possible occurrence of future trouble.

Diagnosis.—When an acute attack is at its height, the diagnosis has to be made from: (1) appendicitis, (2) volvulus, (3) tubercular peritonitis, and (4) intestinal stenosis.

It must be mentioned, however, that though the points previously referred to will often prove of considerable assistance in establishing a correct diagnosis, there is no one sign pathognomonic of invagination of Meckel's diverticulum—the recognition of the lesion must depend on the presence of a combination of signs, such as will be found only in a certain percentage of cases.

As an example, I will emphasize the importance of noticing the appearance of the umbilicus for any marked abnormality here (or a history of persistent discharge of pus or fecal matter in childhood) in conjunction with a typical history of recurrent abdominal crises, or with a palpable sausage-shaped tumor in a case where no blood has been passed per rectum, would warrant the diagnosis of the lesion under consideration. It is unnecessary to again detail the signs already mentioned, for a combination of any of them may suffice to make a diagnosis probable, where the presence of all of them would render this probability a certainty.

From appendicitis the differentiation would depend on the past history, the age, the more gradual onset during activity, culminating in a climax of absolute constipation, the absence of marked local tenderness or rigidity, the character of the pain, etc., etc. The picture of acute appendicitis is quite different, while the recurring attacks of this disease are, as may be readily seen, of a typically different nature.

From volvulus[10] the diagnosis should seldom be difficult, for the age, the sudden and violent nature of the onset, and a consideration of the past history, in conjunction with negative signs, should suffice to render clear the nature of the case. In volvulus, if there have been recurrent attacks, recovery from these latter will usually be accompanied by the passage of a large quantity of flatus, whereas in invagination of Meckel's diverticulum flatulence is more usual.

From subacute (possibly merging into acute) obstruction, due to tubercular peritonitis, the diagnosis may be difficult; for recurrent colicky pains with the passage of blood and possibly mucus may make the case puzzling. The pronounced wasting in such tubercular disease, the frequently putty-like fæces and the typical "feel" of such an abdomen, taken in conjunction with the absence of characteristic signs or history of the diverticular lesion, would be the main points of difference. My own case had been mistaken by the medical attendant for tubercular peritonitis.

Calmette's ophthalmotuberculin reaction might be of assistance in some cases, though my own experience has been that this reaction is less reliable in abdominal than in other forms of tuberculosis.

One case has been mistaken for *intestinal stenosis* (Ewald[11]). No comment is required here, except to mention the association of intestinal stenosis or occlusion with hyperinvolution of the omphalomesenteric structures described by Bland-Sutton.[28] The establishment of such a differential diagnosis will seldom be required, and would be made on general lines after a careful attention to details.

Treatment.—Wherever the diagnosis can be made before the occurrence of the final acute attack (and this should be possible in a certain number of cases) exploratory laparotomy with, if present, the removal of the Meckel's diverticulum, should be urged and performed. During the acute attack resection may be necessary or complete reduction may be possible.

In any case, in spite of the high proportion of recoveries recorded when the diverticulum has been left, it is correct treatment to remove this structure. When the adjacent intestine is œdematous or gangrenous, there is considerable risk of the stitches giving, and in these cases it will be, I think, best to cover the sutures with an omental graft and provide efficient drainage against the possible occurrence of a fecal fistula. When the age and condition of the patient warrant resection of the intestine together with the attached gangrenous diverticulum with restoration by immediate anastomosis, this is the ideal and safest procedure; but this step will rarely be justifiable or wise in cases where reduction can so far be effected.

In conclusion I would say that lesions resulting from abnormalities in the involution of the omphalomesenteric structures, of which invagination of Meckel's diverticulum forms a small part, deserve, from their diversity and severity, more attention than has hitherto been given them.

BIBLIOGRAPHY.

[1] Rehn, Verhandl. d. deutsch. Gesellsch. für Chirurgie, 1904, i, 259.
[2] Forgue & Riche, Le Diverticule de Meckel, 1907.
[3] Gray, Brit. Med. Jour., 1907, ii.
[4] Smith, Annals of Surgery, 1904, xl, 743.
[5] Watson Cheyne, Annals of Surgery, 1904, xl, 796.
[6] Bidwell, Lancet, Sept. 7, 1907.
[7] Betham Robinson, Brit. Med. Jour., 1899, 1416.
[8] Zum Busch, Clin. Soc. Trans., xxxvi, 213.
[9] Coffey, Annals of Surgery, 1907, xlv, 42.

[10] Küttner, Beitr. zur klin. Chir., 1898, xxi, 289.
[11] Ewald, Berliner klin. Wochenschrift, 1897, No. 8, 169.
[12] Strauch, Zeitschrift für klin. Med., 1899, xxxviii, 465.
[13] Jäkch, Deutsche Zeitschrift für Chirurgie, 1907, lxxxvii, 192.
[14] Terry, Lancet, 1903, i, 961.
[15] Wainwright, Annals of Surgery, 1902, xxxv, 32.
[16] Kelly, Quoted by Gray, ibid.
[17] Adams, Trans. Path. Soc., London, 1892, xliii, 75.
[18] Weill & Fränkel, Bull. Soc. Anatomique, 1896.
[19] Von Mandach, Lancet, Dec. 14, 1907, 1733.
[20] Heller, Quoted by Watson Cheyne, ibid.
[21] Brunner, Beitr. zur klin. Chir., 1899, xxv.
[22] Maroni, Virchow u. Hirsch Jahresbericht, 1887, ii, 515.
[23] De Quervain, Centralblatt für Chirurgie, 1898, xxv.
[24] Boldt, Med. Record, April 14, 1900.
[25] Treves, Intestinal Obstruction, 1901.
[26] O'Connor, Brit. Med. Journal, 1894, ii, 123.
[27] Cawardine, Lancet, 1904, i, 505.
[28] Bland-Sutton, Quoted by Gray, ibid.
[29] Holbeck, Archiv. für klinische Chirurgie, 1900, lxi.
[30] Von Strubenrauch, Quoted by Watson Cheyne, ibid.
[31] Travers, Lancet, 1902, ii, 1906.
[32] Morrison, Lancet, 1901, ii, 1047.
[33] Pitts, Brit. Med. Jour., 1901, ii, 579.
[34] Eve, Brit. Med. Jour., 1901, ii, 583.
[35] Erdmann, Annals of Surgery, February, 1900, xxxi, 186.
[36] Ingle, Brit. Med. Jour., 1888, i, 648.
[37] Bayer, Centralblatt für Chirurgie, 1900, xxvii, 1138.
[38] Adams, St. Bartholomew's Hosp. Rep., xxvii, 1891.
[39] Studsgaard, Quoted by Watson Cheyne, ibid.
[40] Guyot, Quoted by Forgue and Riche, ibid.